Sreyas International Journal of Scientists and Technocrats, Vol. 1(2) 2017, pp.15-19

RESEARCH ARTICLE

UPS & Cell Tower Static Cooling System

* Sainath Kasubha[1], Suresh Akella[1], Avinash[2], Alurujyothsna[2], Uday raj[2], Prakash Nayak[2]
[1]Department of mechanical Engineering, Sreyas Institute of Engineering and Technology, Hyderabad, India.
[2] U.G.Students, Department of mechanical Engineering, Sreyas Institute of Engineering and Technology, Hyderabad, India.

Received- 11 November 2016, Revised- 31 December 2016, Accepted- 17 January 2017, Published- 27 January 2017

ABSTRACT

The AC is installed with roll bond evaporator, newly designed, tube and fin condenser and rotary compressor. All these three are attached using copper tubes and the refrigerant is supplied which is rotated through this setup. The refrigerant which comes out of the compressor goes into the condenser which is initially at high temperature and then while coming out of the condenser the temperature of the refrigerant is reduced and now it enters the roll bond evaporator through capillary tube in which the low temperature refrigerant is evaporated and then the refrigerant again goes to compressor. The refrigerant used in this project is R-22, tube and fin condenser and 1 ton rotary compressor. Roll bond evaporator, copper tubes, expansion valve are used for assembling of mobile air conditioner and design of AC In the present work, we have attached 6 roll bond evaporators to cool the ups room and connected to throttle valve, compressor condenser with the help of copper tubes. When the AC is switched on the compressor get started and refrigerant enters into compressor condenser. It then enters into the roll bond evaporator and it helps to reduce the room temperature. There are many cell tower rooms in many companies and colleges ups rooms. For best efficiency, life and reliability the temperature needs to be uniformly constant at 23°Celsius. This project also provides a 3D uniform temperature as required by the set point.

Keywords: Roll bond evaporator, Fin condenser, R-22 refrigerant, Mobile air conditioner, 3D uniform temperature.

1. INTRODUCTION OF REFRIGERATION PROCESS

The process of transferring heat between two locations can be termed as refrigeration. This heat transfer mechanism is carried out conventionally by means of mechanical work. Other sources of driving includes magnetism, heat, laser, electricity etc.,

[1] The above mentioned process corresponds to the primary principle of refrigeration. The main components in a refrigeration process include evaporator, refrigerant and condenser. The function of an evaporator is to transfer heat into the refrigerant. The role of the refrigerant is to transfer heat to the condenser. The cooling medium receives heat from the condenser. Basically the heat flow through a substance by particle contact is termed as conduction.

In our project we use six roll bond evaporators which are fixed to the frame as shown in figure 1.

Figure 1.Six roll bond evaporators

*Corresponding author. Tel.:
Email address: sainathkasuba@gmail.com (S.Kasubha)
https://dx.doi.org/10.24951/sreyasijst.org/2017021003
Double blind peer review under responsibility of Sreyas Publications

This frame is placed at the back side of the rack. The racks are present inside the UPS room. Batteries are placed on the racks. Each rack has got around four batteries in it. So there are a number of batteries inside the room which leads to the production of more amount of heat. Only one air Conditioner is fixed inside the room. During summer season due to high temperature, more amount of heat is produced inside the room and the life of the batteries may get reduced. So to overcome this effect, we are using roll bond evaporator along with the air conditioner. Hence the load on the air conditioner will reduce and life of the batteries increases.

2. VAPOUR COMPRESSION REFRIGERATION CYCLE

Vapour-compression refrigeration steam (VCRS) is the one which exhibits refrigerant phase changes. Air-conditioning of automobiles, buildings etc., uses refrigeration cycles for their accurate design. Other applications include commercial and domestic refrigerators, cold storages for storing vegetables, grains, meat etc., large ware houses, transportable storages, rail, air and water transport, and a large number of industrial and commercial services. Chemical plants, oil processing industries, natural gas plants etc., are some examples which extensively make use of these vapour-compression refrigeration systems

[2, 3] Refrigeration as defined earlier may simply be viewed as lowering of temperature in a space which is enclosed by a medium by eliminating the heat from that space by passing to other regions of interest. The instruments which perform these functions are commonly called as refrigerators, air conditioners, geothermal heat pump, air source pumps or chillers.

Liquid refrigerant is used as the tool or a medium which circulates through the system, facilitating vapour compression. This liquid absorbs the heat from the enclosed space which is the region of interest for cooling and consequently disperses the heat elsewhere. Figure shows a conventional single stage vapor compression system. The main components include a condenser, a compressor, a throttle valve (thermal expansion valve or metering device), in addition to an evaporator. The liquid refrigerant medium makes its way in to the compressor initially. It enters in to the compressor in a thermodynamic state also referred as saturated vapor. Here it is compressed to higher pressure which inturn result in higher temperature. Now, the vapor which is hot compressed is in a thermodynamic state. This state is known as superheated vapor and is now predominantly at a pressure and temperature at which its condensation with respect to cooling air and cooling water across the tubes can be facilitated. At this state, the circulating refrigerant removes the system heat and carries away the heat by means of air or water depending upon the case.

Now the liquid refrigerant which is condensed is in the thermodynamic state. This state is comprised of the saturated liquid which is next guided to the throttle valve. Here sudden decrease in pressure is done which results in a part of the liquid refrigerant being adiabatically flash evaporated. The auto-refrigeration effect of the adiabatic flash evaporation lowers the liquid and vapor refrigerant mixture temperature. Next the mixture which is in a cold sate is routed through the evaporator coil. Parallel, the circulating air gets cooled thereby lowering the enclosed space temperature to the desired temperature. Next it is the evaporator, where the liquid refrigerant absorbs the haeat and removes them which is consequently rejected in the condenser and carried to other places by the air or water present in the condenser.

2.1. Stages of the vapor-compression refrigeration cycle

Basically four steps comprise the refrigeration cycle. The conceptual figure shown in figure 2 shows the PV changes during each part [4, 5].

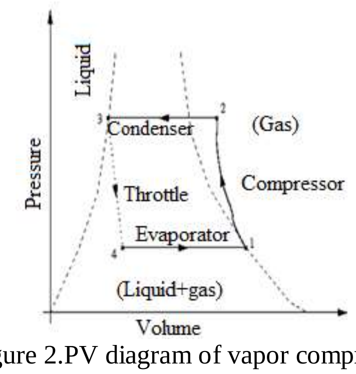

Figure 2.PV diagram of vapor compression refrigeration cycle

2.1.1. Compression

Here the refrigerant enters the compressor part in gaseous state under low pressure and temperature. Next the, adiabatic compression of refrigerant takes place, leaving the compressor under high temperature and pressure.

2.1.2. Condensation

This resulting high pressure and temperature releases heat and condenses inside the condenser. The hot reservoir and condenser of the refrigeration system is in contact with each other. Due to the external work added to the gas the hot reservoir releases the gas. Now the refrigerant can be viewed as a liquid with high pressure.

2.1.3. Throttling

Now the high pressure liquid refrigerant enters the expansion valve thereby causing its expansion. The resulting refrigerant now has lower temperature and pressure while remaining at liquid phase. Thin slit or a plug with holes cvan be used as the thermal valve. Once the refrigerant is forced through the throttle, the pressure gets reduced causing liquid expansion.

2.1.4. Evaporation

The refrigerant which is now in a low temperature and pressure state enters the evaporator. The cold reservoir is connected to the evaporator. As low pressure is maintained, at the same temperatures the refrigerant is able to boil. So, the liquid rejects the heat from the reservoir and evaporates. This leaves the evaporator at a low temperature and pressure which is now taken back to the compressor thereby continuing the cycle.

3. AIR CONDITIONING

The process of changing the air properties to more comfortable conditions is called air conditioning. The primary aim is to distribute the conditioned air to any occupied sopace such as vehicle or building so that the indoor air quality and thermal comfort are improved. Commonly referred, an air conditioner is a device which removes heat from inside the vehicle or building, thereby lowering the air temperature. The cooling effect is typically achieved through refrigeration cycle, but sometimes free cooling or evaporation is used.

3.1. Refrigerant development

The refrigerators and air conditioners employed flammable or toxic gases, such as methyl chloride, ammonia propane etc., which could lead to fatal accidents on their leakage. Thomas Midgley Jr created the first non-flammable and non-toxic chlorofluorocarbon gas, Freon, in 1928. The name is a trademark name owned by DuPont for any chlorofluorocarbon (CFC), hydrochlorofluorocarbon (HCFC) and hydro fluorocarbon (HFC) refrigerant. The refrigerant names include the number indicating the molecular composition (e.g., R-11, R-12, R-22, R-134A). HCFC is the blend which is most commonly used in building comfort cooling and direct-expansion home and is an HCFC referred as chlorodifluoromethane (R-22).

3.2. Refrigerants

This colourless gas is better known as HCFC-22 or R-22.It is commonly used as a propellant and refrigerant. These applications are being phased out in some developed countries due to the compound's high Global Warming Potential (GWP) and Ozone Depletion Potential (ODP), although R-22 refrigerant global use continues to increase because of high demand in developing countries. R-22 is a versatile intermediate in industrialorganofluorine chemistry, e.g. as a precursor to tetrafluoroethylene. R-22 cylinders are coloured light green.

4. PRODUCTION AND CURRENT APPLICATIONS

Worldwide production of R-22 in 2008 was about 800 Gg per year, up from about 450 Ggper year in 1998, with most production in developing countries. [6, 7] R-22 use is increasing in developing countries, largely for air conditioning applications. Air conditioning sales are growing 20% annually in India and China. R-22 is prepared from chloroform:

$$\mathrm{HCCl_3 + 2HF \rightarrow HCF_2Cl + 2HCl}$$

An important application of R-22 is as a precursor to tetrafluoroethylene. This conversion involves pyrolysis to give difluorocarbene, which dimerizes: [8]

$$\mathrm{2CHClF_2 \rightarrow C_2F_4 + 2HCl}$$

The compound also yields difluorocarbene upon treatment with strong base and is used in the laboratory as a source of this reactive intermediate. [9, 10] The pyrolysis of R-22 in the presence of chlorofluoromethane gives hexafluorobenzene.

- True ranges of 20 to 50˚F. It works with MO, AB, and POE oils.
- R-427A is for use in air conditioning and refrigeration applications.It does not require all the mineral oil to be removed. It works with MO, AB, and POE oils [11, 12].
- R-434A is for use in water cooled and process chillers for air conditioning and medium- and low-temperature applications.
- It works with MO, AB, and POE oils.
- R-438A is for use in low-, medium-, and high-temperature applications. It is compatible with all lubricants.

4.1. Physical properties

The physical properties are tabulated in table 1.

Table 1.Physical properties

Property	Value
Density (ρ) at -69 °C (liquid)	1.49 $g.cm^{-3}$
Density (ρ) at -41 °C (liquid)	1.413 $g.cm^{-3}$
Density (ρ) at -41 °C (gas)	4.706 $kg.m^{-3}$
Density (ρ) at 15 °C (gas)	3.66 $kg.m^{-3}$
Specific gravity at 21 °C (gas)	3.08 (air = 1)
Specific volume (ν) at 21 °C (gas)	0.275 $m3.kg^{-1}$
Density (ρ) at 15 °C (gas)	3.66 $kg.m^{-3}$
Triple point temperature (T_t)	
Critical temperature (T_c)	96.2 °C (369.3 K)
Critical pressure (p_c)	4.936 MPa (49.36 bar)
Vapor pressure at 21.1 °C (pc)	0.9384 MPa (9.384 bar) [10]
Critical density (ρ_c)	6.1 $mol.l^{-1}$
Latent heat of vaporization (lv) at boiling point (-40.7 °C)	233.95 $kJ.kg^{-1}$
Heat capacity at constant pressure (Cp) at 30 °C (86 °F)	0.057 $kJ.mol^{-1}.K^{-1}$
Heat capacity at constant volume (Cv) at 30 °C (86 °F)	0.048 $kJ.mol^{-1}.K^{-1}$
Heat capacity ratio (γ) at 30 °C (86 °F)	1.178253
Compressibility factor (Z) at 15 °C	0.9831
Acentric factor (ω)	0.22082
Molecular dipole moment	1.458 D
Viscosity (η) at 0 °C	12.56 μPa.s (0.1256 cP)
Ozone depletion potential (ODP)	0.055 (CCl_3F = 1)
Global warming potential (GWP)	1810 (CO_2 = 1)

4.2. Calculation

Temperature and its specification are given in table 2.

Table 2.Temperature range

Temperature	Range
Average initial temperatures T	33
Average of Return temperatures T1	27
Average temperature of discharge T2	28
Average temperature of liquid line T3	26
Average temperature of shell top T4	30

When h = enthalpy T = temperature, their specifications are given in table 3.

Table 3.Enthalpy vs. temperature

h_1 at T_1	236.6KJ/KG
$h_2$at T_2	231.5KJ/KG
h_3 at T_3	234.1KJ/KG
h_4 at T_4	232.8KJ/KG

The relations for heat rejection, heat addition and coefficient of performance are stated below,

Heat rejected (QR)

QR = (h2-h3) + (h3-h4) KJ/KG

QR = (234.1-231.5) + (231.5-232.6)

QR = 1.5KG/KJ

Heat addition (QS)

QS = h1-h4 KJ/KGK

QS = 236.6-232.8

QS = 3.8 KJ /KGK

Coefficient of performance (COP)

COP = QS/ (QS - QR)

COP = 3.8 / (3.8-1.5)

COP = 1.65

5. CONCLUSION

After conducting the experimentation and testing, we understood the future scope of our work. We can with stand-up room with 23 degrees.Hence, we can say that ups cell tower static cooling system and very economical when compared to traditional split or window air conditioner.

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